northwest until it leaves the post. Although it is a shallow creek, it usually has a constant flow of water (Gossweiler 1984).

In the winter of 1996-1997, the main and North Fork channels of Chester Creek were damaged during construction of the Municipality of Anchorage's 48-inch water transmission line. The damage occurred in a wetland area the creek passes through, near the western boundary of Fort Richardson, and adjacent to the Muldoon Community in east Anchorage. The main channel was blocked with ice and the creek overflowed onto the property of nearby homeowners. The threat of flooding homes caused the contractor to drain excess water into the city's storm drain. In addition to the flooding problem, the stream was improperly reconstructed across the pipeline right-of-way.

The ADF&G, the Alaska Department of Environmental Conservation, and the Alaska District, Corps of Engineers sent Notices of Violation (NOVs) to the Municipality of Anchorage Water and Wastewater Utility for violating existing stipulations for pipeline construction or for failing to obtain the required permits for the work performed. The improper alteration of Chester Creek was satisfactorily repaired in August 1997, and wetland vegetation plugs were transplanted adjacent to the creek. Other construction damage on the North Fork, where it crosses the pipeline right-of-way, resulted in the creek bottom being above grade, which caused alternating conditions of ponding and dewatering.

The North Fork of Campbell Creek drains a lake in the Chugach Mountains eight miles southeast of the post. It passes through Fort Richardson flowing northwest from the southern boundary to the western boundary. The creek is particularly scenic, and its water is quite clear. A waterfall is located in the southwest corner of the post (Gossweiler 1984).

2.2.4.1.2 Lakes and Ponds

Fort Richardson has 12 named lakes and ponds and several unnamed water bodies. The combined area for the named lakes and ponds is 348 acres. Five relatively large lakes, Clunie, Otter, Gwen, Thompson, and Waldon, are managed for recreational fishing.

Clunie Lake.

Clunie Lake (116 acres) is the largest lake on the post. It is picturesque and situated in the northern, moraine area of Fort Richardson. It attains a maximum depth of approximately 33 feet and drains into Clunie Creek (Gossweiler 1984).

Otter Lake covers 93 acres and is the post's second largest lake. It receives the most fishing pressure. It is fed by a small creek on its southern end and drains into Otter Creek on its northern end. It attains a depth of 23 feet (Gossweiler 1984).

Gwen Lake is small and shallow with an area of 10 acres and a maximum depth of 11 feet. It is located two miles north of the cantonment area along a well-maintained road. Due to its small size and lack of depth, it cannot support fish over winter (Gossweiler 1984).

Thompson Lake is smaller but deeper than Gwen Lake. Its eight acres make it the smallest of the actively-managed lakes on Fort Richardson. It attains a depth of 21 feet and can support fish over winter (Gossweiler 1984).

Waldon Lake is approximately 50 acres. It is only about eight feet deep, therefore it may not support fish during some winters. This lake is easily accessed.

The other seven lakes and ponds on the post are: Chain Pond, Web Pond, Lake Kiowa, Dishno Pond, Cochise Lake, Diablo Pond, and Snowhawk Lake. Snowhawk Lake is located in the southeastern corner of Fort Richardson and is the largest and least accessible of the seven. None of these other lakes or ponds support a fishery, except Dishno Pond which

Gwen Lake.

is stocked annually with catchable-sized rainbow trout for flyfishers. About 80 percent of Campbell Lake lies within Fort Richardson.

2.2.4.1.3 Salt Water

Roughly 12 miles of shoreline along the Knik Arm of Cook Inlet form the northern border of Fort Richardson. Eagle Bay is located in the southern portion of this area, where Knik Arm merges with the Eagle River. Tidal activity in Eagle Bay has created an estuarine salt marsh encompassing ERF Impact Area. Numerous ponds dot the marsh. Many of these are shallow mudflat ponds, less than 6 inches deep that often dry up during summer. Others are more permanent and achieve depths of over 4 feet. These deeper ponds often are fed by freshwater streams and springs.

In 1994, a comprehensive evaluation of ERF was conducted to address water quality of these ponds (CH2M Hill 1994b). The salinity level varied from 1 to 46 parts per thousand (ppt). Salinity in most ponds was below 10 ppt. Tidal flooding of ERF infuses ponds with saltwater and sediments from Eagle Bay. Elevation determines frequency of floods, varying from mean sea level (msl) to 18 feet above msl. Flooding may occur daily during high tides in areas less than 12 feet above msl. In areas from 12 feet to 13 feet above msl, flooding occurs only with the highest tide each month, and in areas above 13 feet, flooding occurs only during extremely high tides (CH2M Hill 1994).

ERF is an estuarine salt marsh created by tidal activity.

2.2.4.2 Groundwater

Two freshwater aquifers underlie most of Fort Richardson. These aquifers flow west from the Chugach Mountains to the Cook Inlet and are recharged by groundwater originating from precipitation in the mountains. The two aquifers lie in different soil strata, and are separated by a 60 to 200-foot layer of impermeable Bootlegger Cove Clay. The upper, unconfined aquifer lies in a 30 to 100-foot layer of well-bedded and well-sorted gravel near the surface. This aquifer usually can be accessed at depths of less than 50 feet (CH2M Hill 1994b).

The lower, confined aquifer lies in a 100 to 200 foot-layer of sand and gravel. The impermeable clay above produces artesian conditions and protects the lower aquifer against seepage and pollutants from the surface, thus the water quality of this artesian aquifer is excellent. It is estimated that 75 million gallons of water originating from the mountains recharge the aquifer each day. This aquifer usually can be accessed from 200 feet to 400 feet below the surface. Wells drilled into the aquifer can produce up to 1,500 gallons of water per minute (CH2M Hill 1994b).

Industrial activities associated with Army occupation on Fort Richardson have had some minor effects on groundwater. These effects are associated with underground storage tanks, facilities where chemicals were stored, and places where chemicals were dumped. These areas are now being monitored intensively, and there have been no indications of deep groundwater pollution. Pollution has been minor, localized, and there has been no significant risk to human health. Recently, water quality has tended to improve as Army restoration projects mitigate earlier damage to the quality of groundwater.

2.2.5 Climate

By Alaskan standards, the Anchorage area has a moderate climate. Fort Richardson is in a transition zone between the northern continental climate of the Alaskan interior and the maritime climate of the Gulf of Alaska. The Alaska Range to the north and northwest of the post acts as a barrier to very cold air from the interior. The Kenai and Chugach Mountains to the south and east prevent the influx of maritime air from the Gulf of Alaska. The waters of the Cook Inlet and the Knik Arm serve to moderate temperatures and provide moisture (Elmendorf AFB 1994).

Fort Richardson has a long winter with subfreezing temperatures that usually lasts from mid-October to mid-April (see Table 2-1). High pressure weather systems during this period may lead to successive days with temperatures below minus 35 degrees Fahrenheit (F). The spring is marked by the ice “break-up” starting in mid-April and lasting until June, characterized by a rapid rise in temperature. Summer lasts from June to early September, and has a daily average temperature of 56 degrees F. Autumn on Fort Richardson is brief, lasting from about mid-September to mid-October.

According to a number of scientists, the effects of global warming are already taking a toll in Alaska. Damage to forests, loss of salmon habitat and widespread melting of permafrost are being attributed to a permanent and significant climate regime shift. Major changes in temperature, warming of rivers and extensive melting of permafrost have been clearly evidenced in both Alaska and Canada over the last 20 years.

Tree growth studies conducted by University of Alaska Professor, Glenn Juday, have found clear indication that normal cycles of forest growth started changing dramatically in the early to mid 1970s. The studies also show that the forests have been experiencing stresses since then, often involving complex interactions of different effects of warming that have no precedent in the historical record. This could eventually lead to the boreal forest dying out and being replaced with grassland steppe vegetation that covered much of interior Alaska in the Pleistocene Period ten thousand years ago. The melting of permafrost creates sinkholes and differential settling of the ground that damage roads, building foundations, airports, and other man-made structures. Significant amounts of salmon spawning habitat may be lost due to stream warming.

Table 2-1. Average Temperatures (Degrees Fahrenheit) by Month, March 1941-December 1991 for the Fort Richardson Area (Elmendorf AFB 1994).

Month	**Average**		**Mean**	**Extremes**	
	High	**Low**		**Maximum**	**Minimum**
January	19	5	12	49	38
February	25	10	18	58	33
March	32	15	24	51	24
April	43	28	35	65	20
May	54	39	47	80	12
June	62	47	55	86	33
July	65	51	58	83	35
August	63	49	57	82	29
September	55	42	49	74	20
October	41	29	35	63	6
November	27	15	21	57	20
December	19	7	13	53	34
Annual	42	26	35		

Fort Richardson's winters are long.

Although thermokarst (melting of permafrost) is not a major problem in most parts of south-central Alaska due to only small isolated areas being underlain with permafrost, spruce bark beetle (*Dendroctonus rufipennis* [Kirby]) infestations have reached epidemic proportions during the 1990s. Warmer than average summers and other climatic conditions, as well as large tracks of mature, even-aged, and unhealthy spruce forests, have contributed to the beetle outbreak. Activity levels in south-central Alaska have increased to nearly a million acres of active infestation (Dr. Edward Holsten pers. com.). The damage is resulting in the catastrophic long-term loss of 60-80 percent of spruce trees larger than 9 inches in diameter. The infestations reduce forest diversity and increase fuel loading, which substantially increases forest fire danger in the affected areas.

Soils on Fort Richardson are subject to seasonal freezing. The average last date for a killing frost is May 15, and the average first date for a killing frost is September 8, providing a 115-day growing season (Elmendorf AFB 1994). Average monthly temperatures for the Anchorage area are provided in Table 2-1. Permafrost on Fort Richardson is all but absent, probably occurring only as remnants from the last Ice Age, deep within peat deposits.

Prevailing winds come from the west in summer and from the north and northeast in winter. Average wind velocity is six miles per hour (mph). Channeling of south and southeasterly winds passing over the Chugach Mountains, during low pressure systems called "chinooks," can lead to wind gusts up to 100 mph. These gusts can inflict significant property damage (Gossweiler 1984).

Approximately 40 percent of the 15-inch annual precipitation falls from mid-July to mid-September (Gossweiler 1984). The six months of winter account for another 40 percent of annual precipitation with an average of 72 inches of snowfall. Spring and autumn combine for a meager 3 inches of the annual precipitation (Elmendorf AFB 1994).

2.3 Biological Resources

2.3.1 Biodiversity

Biodiversity is difficult to quantitatively track with the exception of game species and a few other species of high interest. Although the land was degraded when the Army moved onto Fort Richardson, the extent of that degradation and associated damage to the biodiversity is unknown. Army occupation probably improved overall forest ecosystem biodiversity as timber was allowed to age, with the exception of areas in the lowlands that were damaged and set back successionally.

It is difficult to determine whether the military mission has significantly affected biodiversity. Changes in ecosystems were in all likelihood very localized and may have affected species abundance for relatively short periods, but probably did not affect overall species richness. This is particularly true when Fort Richardson is compared with other surrounding lowland areas. These areas were developed, and biological diversity was decreased significantly, a fate that probably would have happened to much of Fort Richardson's lands had they not been occupied by the Army.

Due to a lack of historical data on the flora and fauna of Fort Richardson, the discussion above is largely speculative. Implementation of this INRMP will improve the capability of the Army to monitor biodiversity trends in future years.

2.3.2 Flora

"I do not believe we could survive without the rest of nature; but most important, what good will it be if we live to inherit a barren world devoid of natural things – the wild things that make life worth living." [9]

2.3.2.1 Vegetative Profile

G. Tande, Alaska Natural Heritage Program, prepared an appendix, *Vegetation of Fort Richardson*, for the floristic inventory of the post (Lichvar et al. 1997). The following is excerpted from that appendix.

Fort Richardson falls within the Cook Inlet Lowlands Section of the Coastal Trough Humid Taiga Province of Bailey's Ecoregions of the United States (McNab et al. 1994). Forests in the Anchorage area closely resemble the Boreal Forest of Interior Alaska, although some understory and tree species occur that are typically found in the Coastal Spruce-Hemlock Forest. Fort Richardson's forests have been described as open, low-growing spruce and closed spruce-hardwood forests by Viereck and Little (1972), and as a lowland spruce-hardwood forest by the Joint Federal-State Land Use Planning Commission (JFSLUP 1973). Packee (1994), in examining Alaska's forest vegetation

Lowland Interior Forest Zone.

Subalpine Zone.

zones, characterizes the region as an area where white spruce (*Picea glauca*) and Sitka spruce (*Picea sitchensis*) naturally hybridize; balsam poplar (*Populus balsamifera*) and black cottonwood (*Populus trichocarpa*) intergrade; and mountain hemlock (*Tsuga mertensiana*) may form the subalpine forest. Vegetation reflects the transitional nature of the climate between maritime and continental. This maritime climatic influence has resulted in a lower incidence of natural fire than is found in the spruce-hardwood forests of interior Alaska (Gabriel and Tande 1983).

Upland sites on Fort Richardson are dominated by paper birch (*Betula paperifera*), white spruce, and, on drier sites, quaking aspen (*Populus tremuloides*). Cottonwood and poplar are common in areas bordering principal streams. Black spruce (*Picea mariana*) is the dominant tree in wetter areas and on some well-drained sites. Most bogs are treeless or support stands of stunted black spruce. Grasses, herbs, willows (*Salix* spp.), and alders (*Alnus* spp.) dominate the vegetation in a narrow band along the inlet and at elevations above 1,500 feet on the Chugach Mountain slopes.

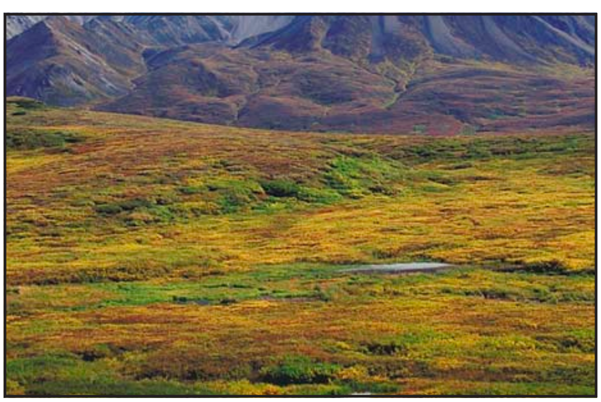
White spruce, mountain hemlock, and, to a lesser extent, balsam poplar, are the dominant treeline species in south-central Alaska (Viereck et al. 1992). At upper elevations, graminoid forb meadows, alder, and dwarf birch (*Betula glandulosa/nana*) thickets give way to low-growing alpine vegetation in the Chugach Mountains.

Fort Richardson Military Reservation is a topographically diverse area varying from mudflats inundated by the tides of Cook Inlet to mountain

[9] Sir Peter Scott.

peaks of over 5,300 feet. Many different vegetation communities are represented, from coastal salt marsh and boreal forest types to high alpine tundra, talus slopes, shrublands, snowbeds, heaths, and meadows. The following five zones of vegetation and plant habitats were recognized for the purposes of the floristic inventory:

- **COASTAL HALOPHYTIC ZONE** influenced by salt water, principally including shoreline tidal flats and the 2,137-acre ERF estuarine marsh on Cook Inlet.
- **LOWLAND INTERIOR FOREST ZONE** of boreal forest habitats below approximately 1,500 feet. Mesic to dry forest types include: white spruce, white spruce-paper birch, paper birch, white spruce-cottonwood, black cottonwood-balsam poplar, and quaking aspen. Wetlands are predominantly black spruce tree bogs and treeless bogs with a variety of low shrub and graminoid forb communities. Alder shrub is a dominant type of the Lowland Interior Forest Zone.
- **SUBALPINE ZONE** of intermittent forest, shrub, and meadow habitats from approximately 1,500 feet to 2,500 feet elevation. Mesic to dry sites include white spruce, white spruce-paper birch, balsam poplar, and mountain hemlock. Forests are interspersed with alder shrub and grass forb meadows. Treeless bogs are occasionally present in the Subalpine Zone.
- **ALPINE ZONE** of mountain landscape habitats above treeline. Low shrubs and dwarf shrubs occupy wet and mesic to dry habitats. The latter include mesic to dry vegetated sites and dry non-vegetated sites such as rock talus and blockfields. Wetter habitats include late-melting snowfields and snowbeds.



Alpine Zone.

- **ARTIFICIALLY CLEARED OR DISTURBED ZONE** of the cantonment area, utility corridors, roadsides, railroad rights-of-way, borrow pits, wood cutting areas, moose habitat areas, small arms ranges, firing points, landing zones, and other human-modified areas.

2.3.2.2 Floristic Inventory

A comprehensive floristic inventory of Fort Richardson was conducted in 1994 (Lichvar et al. 1997). The inventory included vascular plants, ferns and fern allies, the more common mosses, liverworts, and lichens. The University of Alaska, Fairbanks, assisted with the lichens, mosses, and liverworts. Fort Richardson has one set of archival herbarium mounts and one set of specimens laminated in plastic for use during fieldwork.

Plants were collected from six areas at 98 collecting sites. A total of 1,087 vascular plant collections were made. The inventory found 561 vascular species (588 taxa including subspecies and varieties), in 75 families and 246 genera. At least 75 species collected represented extensions in known ranges. Fort Richardson has about 30 percent of Alaska's vascular flora (Lichvar et al. 1997).

A total of 986 collections were made of cryptogams. The inventory found 239 species (256 taxa including subspecies and varieties), which represented 19 hepatics, 112 lichens, and 108 mosses (Lichvar et al. 1997).

Elmendorf AFB (1994) lists vascular plants, mosses, and lichens found on the base during the 1982-1983 Resources Inventory. This list is generally applicable to Fort Richardson.

2.3.2.3 Threatened or Endangered, and Species-of-Concern Plants

A comprehensive survey of rare plants was included as part of the floristic inventory for Fort Richardson conducted in 1994. Only two plant species on the federal endangered species list are known to occur in Alaska. Neither species' current or historic ranges include Fort Richardson, and a report released in 1995 indicated that there are no federally listed endangered or threatened plant species on Fort Richardson (Lichvar et al. 1997). There is, however, one former category 2 candidate species, *Taraxacum carneocoloratum*, found in alpine areas of the Chugach Mountains. This plant has been discovered at an increasing number of sites in Alaska, and its candidate status may be reevaluated.

There are also 22 vascular plant species-of-concern that are known to occur on Fort Richardson. These plants are being tracked by the Alaska Natural Heritage Program because they are thought to be uncommon or rare in Alaska and/or uncommon or rare globally (Alaska Natural Heritage Program 2000). These species are listed below in Table 2-2 and are documented in the survey results of Lichvar et al. (1997). Many of these plants are alpine natives and this ecosystem is also the most vulnerable to the effects of military training. There are no legal ramifications from these listings; rather they are generated by the Heritage Program to help track the occurrence of these taxa across the state as more botanical work is conducted. The categories listed do not indicate known threats to these species, but they do represent the rather few collections known for each taxa in Alaska and the geographic distribution of those collections. All of these taxa are listed for management in the ecosystem management program for Fort Richardson (see Chapter 3).

2.3.2.4 Vegetation Mapping

CEMML-CSU initiated vegetation mapping on Fort Richardson in 1995. Mapping was done in two phases: remote sensing and ground truthing. Color aerial photos of the post taken in 1995 and other

Table 2-2. Rare Plant Species Occurring on Fort Richardson.

SPECIES	**ALASKA NATURAL HERITAGE PROGRAM RANKINGS**	
	GLOBAL	**STATE**
Aphragmus eschscholtzianus	rare or uncommon	rare or uncommon
Arnica ovata	demonstrably secure	critically imperiled
Carex deweyana	demonstrably secure	unranked or critically imperiled
Cassiope lycopodioides ssp. cristapilosa	cause for concern/demonstrably secure	critically imperiled
Douglasia alaskana	imperiled/rare or uncommon	imperiled/rare or uncommon
Draba ruaxes	rare or uncommon	rare or uncommon
Eleocharis kamtschatica	cause for concern	imperiled
Eleocharis quinqueflora	demonstrably secure	critically imperiled
Eriophorum viridi-carinatum	demonstrably secure	imperiled
Glyceria striata ssp. stricta	demonstrably secure	imperiled
Minuartia biflora	demonstrably secure	imperiled
Myriophyllum verticillatum	demonstrably secure	rare or uncommon
Najas flexilis	demonstrably secure	critically imperiled/imperiled
Oxytropis huddelsonii	rare or uncommon	imperiled/rare or uncommon
Papaver alboroseum	rare or uncommon/cause for concern	rare or uncommon
Phalaris arundinacea	demonstrably secure	rare or uncommon
Saxifraga adscendens ssp. oregonensis	cause for concern/demonstrably secure	imperiled/rare or uncommon
Stellaria umbellata	demonstrably secure	imperiled/rare or uncommon
Taraxacum carneocoloratum	rare or uncommon	rare or uncommon
Thlaspi arcticum	rare or uncommon	rare or uncommon
Viola selkirkii	demonstrably secure	rare or uncommon
Zannichellia palustris	demonstrably secure	rare or uncommon

Figure 2-7. Fort Richardson Vegetation.